Announcements

- FINAL EXAM:
  - PHYS 132-001: Wednesday, May 10 @ 10-11:50 am
- Homework for tomorrow…

  Ch. 23, Probs. 20, 22, & 24

  23.10: 35°

  23.12: 31°

  23.52: 35°
- Office hours…

  MW 10-11 am

  TR 9-10 am

  F 12-1 pm
- Tutorial Learning Center (TLC) hours:

  MTWR 8-6 pm

  F 8-11 am, 2-5 pm

  Su 1-5 pm

Chapter 23

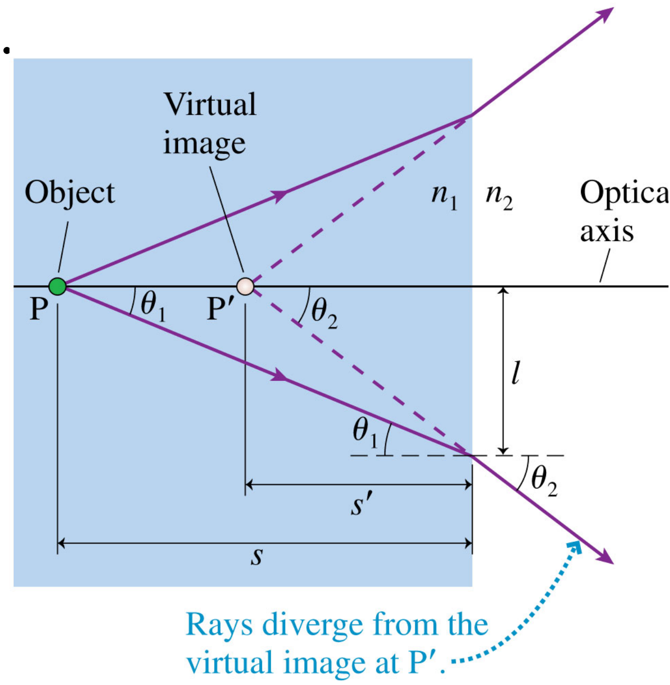
Ray Optics

(Image Formation by Refraction & Color and Dispersion)

Last time…

- *Image formation from refraction..*

$$\boxed{s' = \frac{n_2}{n_1} s}$$

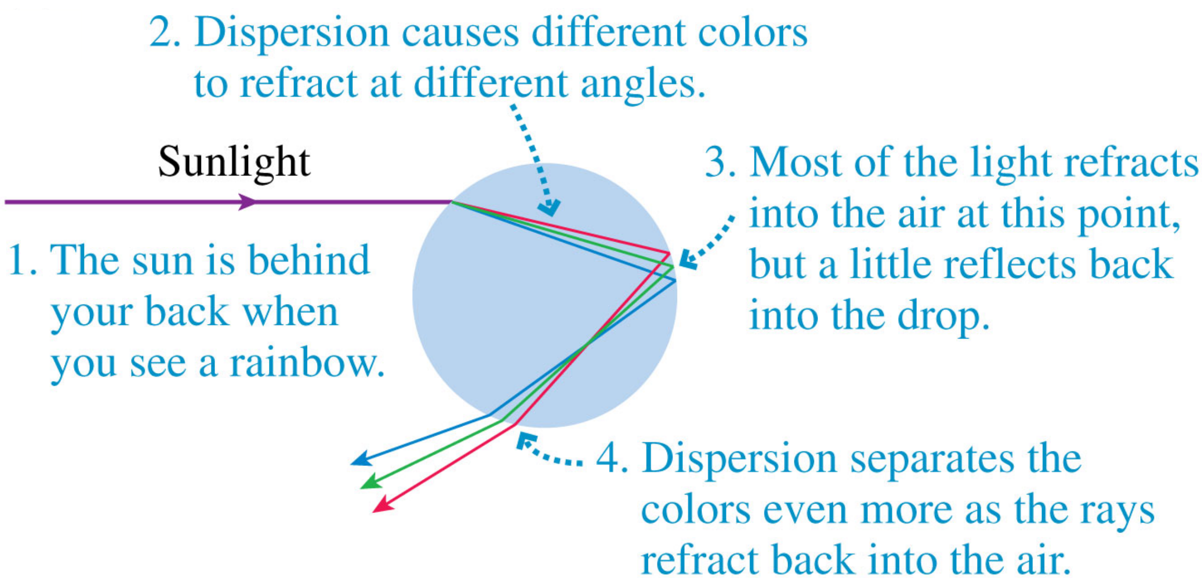


- *Dispersion…*

$$\boxed{n = n(\lambda)}$$

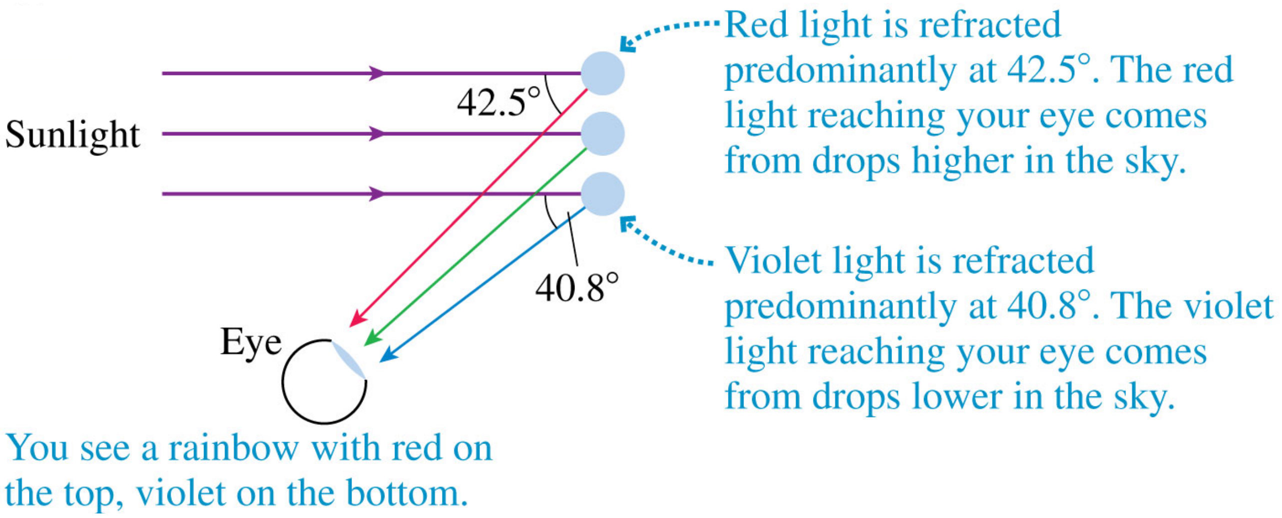
Rainbows…

- The basic cause of the rainbow is a combination of *refraction, reflection, and dispersion*.



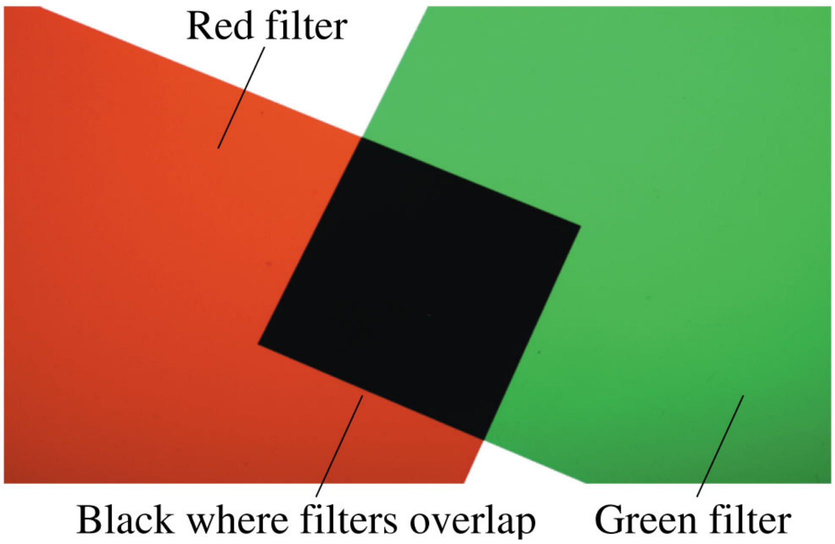
Rainbows…

- A ray of *red* light reaching your eye comes from a drop *higher* in the sky than a ray of *violet* light.
  - You have to look higher in the sky to see the red light than to see the violet light.



Colored Filters and Colored Objects

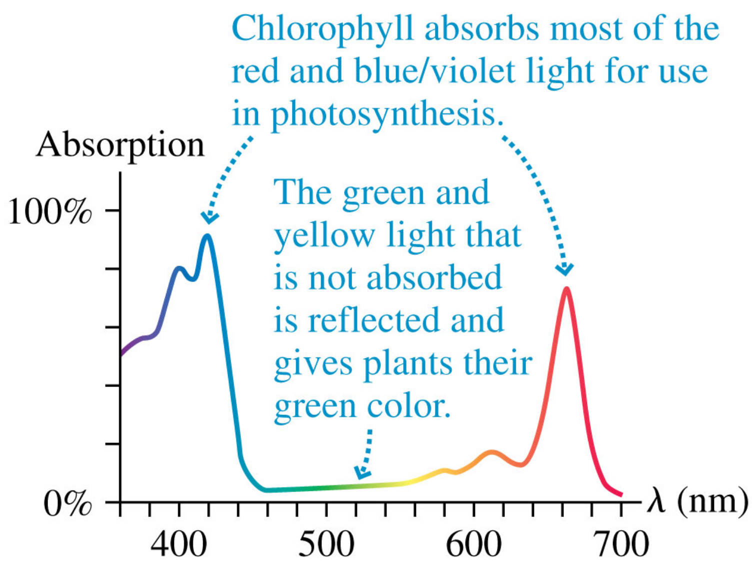
- Green glass is green because it absorbs any light that is "not green."
- If a green filter and a red filter are overlapped, no light gets through.
  - The green filter transmits only green light, which is then absorbed by the red filter because it is "not red."



Colored Filters and Colored Objects

- The figure shows the absorption curve of *chlorophyll*, which is essential for photosynthesis in green plants.
- The chemical reactions of photosynthesis absorb red light and blue/violet light from sunlight and put it to use.

- When you look at the green leaves on a tree, you're seeing the light that was reflected.



Light Scattering: Blue Skies and Red Sunsets

Q: Why is the sky blue?

Q: Why are sunsets red/orange?

Light Scattering: Blue Skies and Red Sunsets

Q: Why is the sky blue?

Q: Why are sunsets red/orange?

A: *Rayleigh scattering*!

Light Scattering: Blue Skies and Red Sunsets

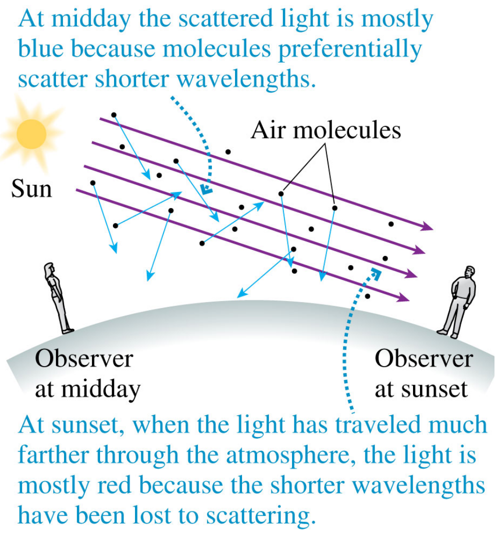
- If particles are *large* compared to the *wavelengths of light*…
  - *Law of Reflection* holds (which does NOT depend on wavelength)
  - All colors are equally scattered
  - i.e.'s: clouds & milk

- If particles are *small* compared to the *wavelengths of light*…
  - *Rayleigh Scattering* (atomic-level scattering)
  - DOES depend on wavelength!

$$\boxed{I_{scattered} \propto \frac{1}{\lambda^4}}$$

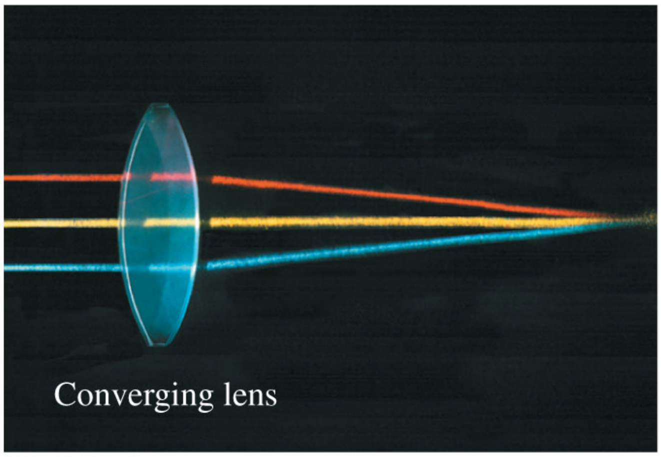
Notice:

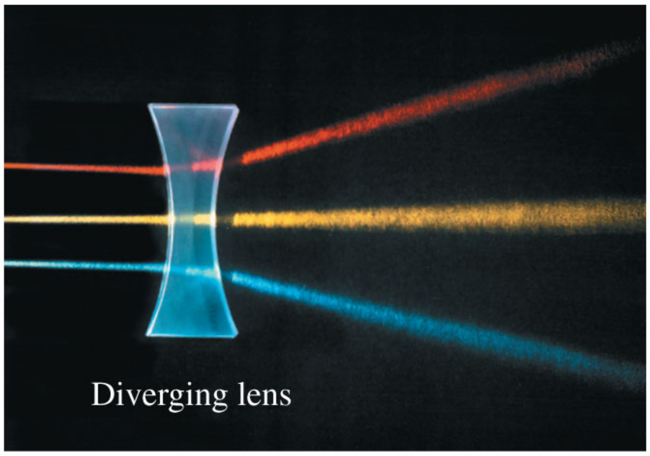
Shorter wavelengths are preferentially scattered!



23.6
Thin Lenses: Ray Tracing

- Photos show parallel light rays entering 2 different lenses…
- The left lens (*converging lens)* refracts parallel rays *toward* the optical axis.
- The right lens (*diverging lens*) refracts parallel rays *away from* the optical axis.





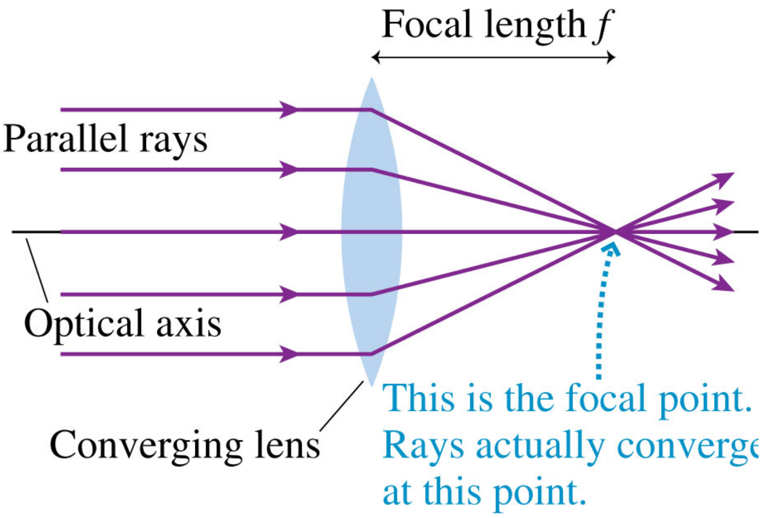
23.6
Thin Lenses: Ray Tracing

A *converging lens* is thicker in the center than at the edges.

The *focal length, f,* is...

- the distance from the lens at which rays parallel to the optical axis *converge*.

- a property of the lens, *independent* of how the lens is used.

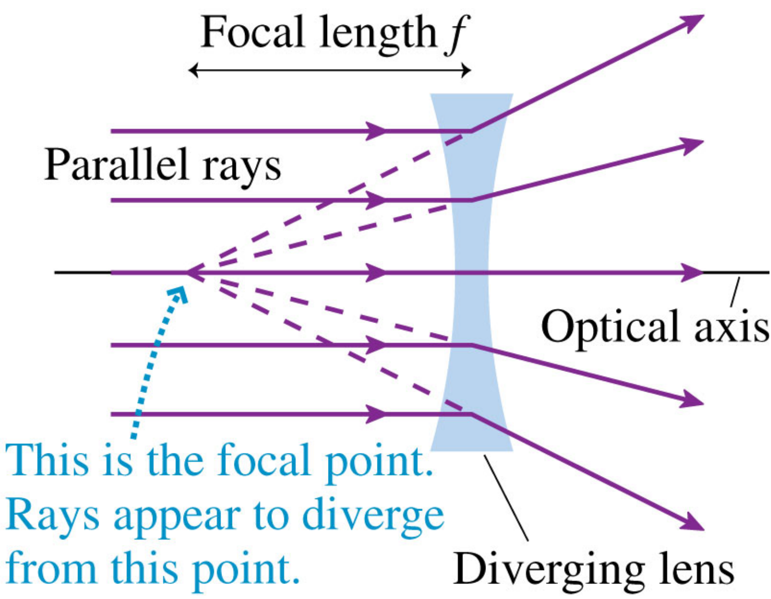


23.6
Thin Lenses: Ray Tracing

A *diverging lens* is thicker at the edges than in the center.

The *focal length*, *f,* is…

- the distance from the lens at which rays parallel to the optical axis *appear* to *diverge* from.
- a property of the lens, *independent* of how the lens is used.



Quiz Question 1

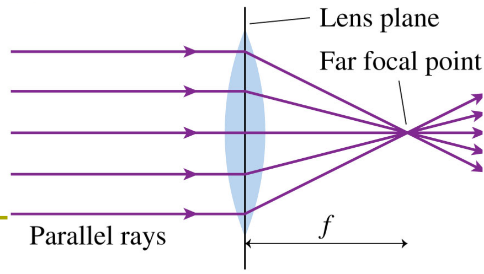
You can use the sun's rays and a lens to start a fire. To do so, you should use

1. a converging lens.
2. a diverging lens.
3. either a converging or a diverging lens will work if you use it correctly.

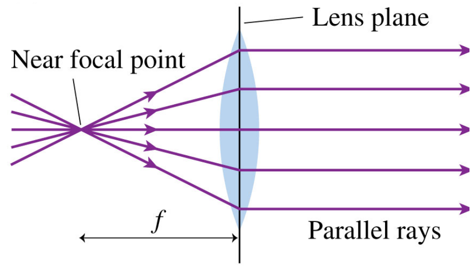
23.6
Thin Lenses: Ray Tracing

3 situations form the basis for ray tracing through a thin *converging lens*.

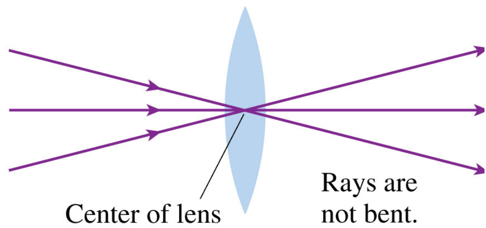
1. A ray initially *parallel* to the optical axis will go through the *far focal point* after passing through the lens.
2. A ray through the *near focal point* of a thin lens becomes *parallel* to the optical axis after passing through the lens.
3. A ray through the *center* of a thin lens is neither bent nor displaced but travels in a *straight line*.



Any ray initially parallel to the optical axis will refract through the focal point on the far side of the lens.

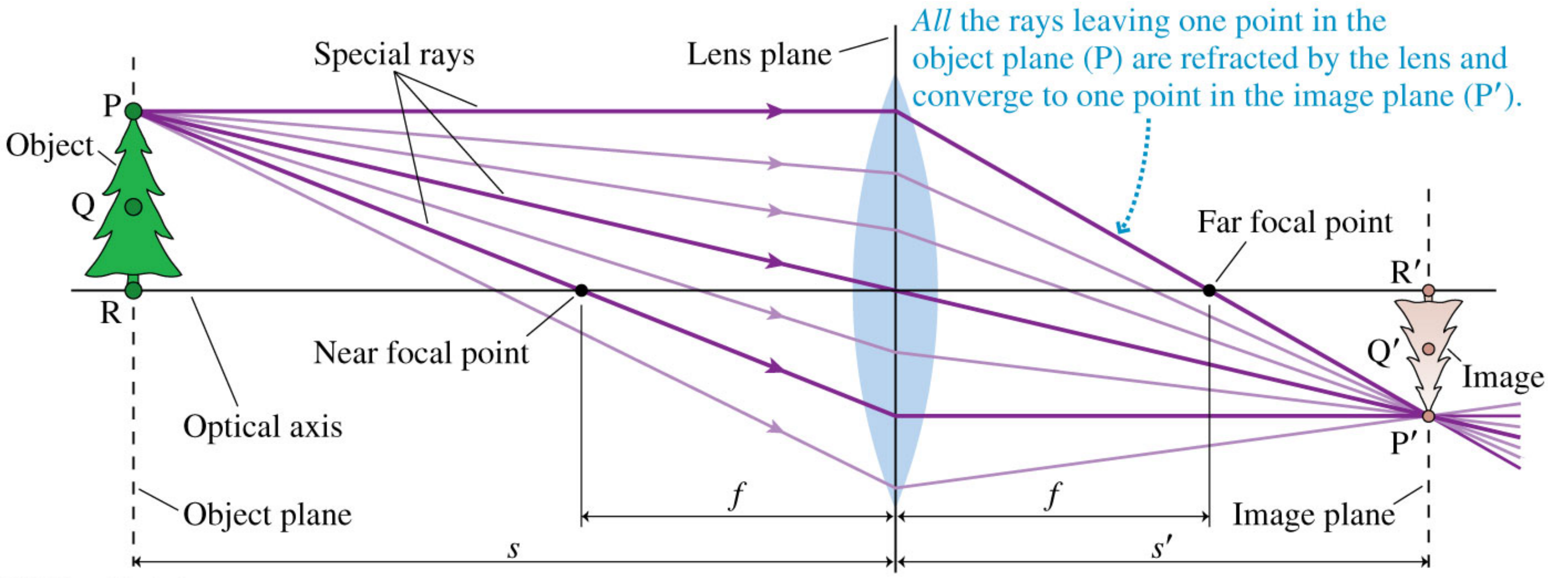


Any ray passing through the near focal point emerges from the lens parallel to the optical axis.



Any ray directed at the center of the lens passes through in a straight line.

23.6 Thin Lenses: Ray Tracing

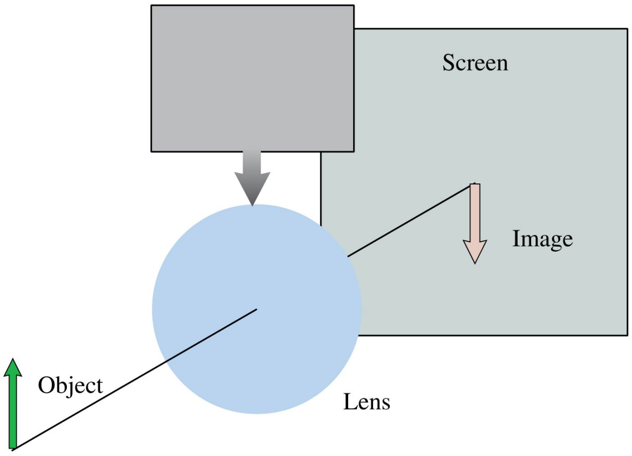


Notice:

- There are 3 *special rays* that will allow us to find our image.
- Every point on the *optical plane* will form an image on the *image plane*.

Quiz Question 2

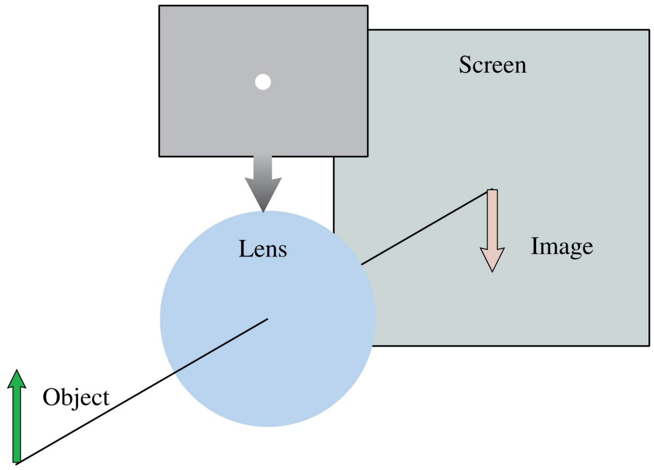
A lens produces a sharply focused, inverted image on a screen. What will you see on the screen if a piece of dark paper is lowered to cover the top half of the lens?



1. An inverted but blurry image.
2. An image that is dimmer but otherwise unchanged.
3. Only the top half of the image.
4. Only the bottom half of the image.
5. No image at all.

Quiz Question 3

A lens produces a sharply focused, inverted image on a screen. What will you see on the screen if the lens is covered by a dark mask having only a small hole in the center?

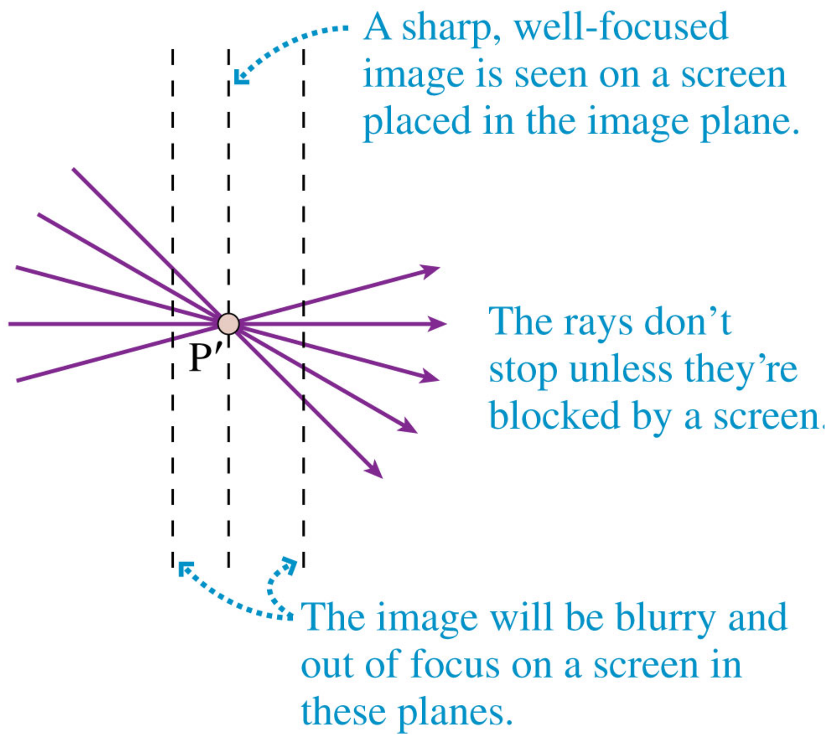


1. An inverted but blurry image.
2. An image that is dimmer but otherwise unchanged.
3. Only the middle piece of the image.
4. A circular diffraction pattern.
5. No image at all.

Image formation….

- The figure is a close-up view of the rays very near the image plane.

- To focus an image, you must either
  - move the screen to coincide with the image plane or
  - move the lens or object to make the image plane coincide with the screen.



i.e. 23.8
Finding the image of a flower

A 4.0 cm diameter flower is 200 cm from the 50 cm focal length lens of a camera.

How far should the light detector be placed behind the lens to record a well-focused image?

What is the diameter of the image on the detector?